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Cost savings of home nocturnal versus conventional in-center hemodialysis

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Cost savings of home nocturnal versus conventional in-center hemodialysis.

Background. Home nocturnal hemodialysis (HNHD) can improve clinical and biochemical factors in people with renal failure, but its cost-effectiveness relative to conventional in-center hemodialysis (IHD) is uncertain. We hypothesized that HNHD would provide more dialysis treatments at a lower total cost than IHD.

Methods. A prospective one-year descriptive costing study was performed at two centers in Toronto, Canada, involving patients enrolled from a HNHD program ($N = 33$), and a matched cohort from an IHD program ($N = 23$). All costs are expressed as mean weekly amount in Canadian year 2000 dollars. A projected mean annual cost (PMA) was calculated also.

Results. The mean number of treatments per week was much higher with HNHD (5.7 vs. 3.0, $P = 0.004$). Cost categories found to be less expensive for HNHD were staffing (weekly \$210 vs. \$423, $P < 0.001$, PMA \$10,932 vs. \$22,056) and overhead and support (weekly \$80 vs. \$238, $P < 0.001$, PMA \$4179 vs. \$12,393). There was a trend toward lower costs for hospital admissions and procedures (weekly \$23 vs. \$134, $P = 0.355$, PMA \$1173 vs. \$6997) and for medications (\$172 vs. \$231, $P = 0.082$, PMA \$8989 vs. \$12,029). Costs found to be more expensive for HNHD were the cost of direct hemodialysis materials (weekly \$318 vs. \$126, $P < 0.001$, PMA \$16,587 vs. \$6575) and capital costs (weekly \$118 vs. \$17, $P < 0.001$, PMA \$6139 vs. \$871), with a trend toward higher cost for laboratory tests (weekly \$33 vs. \$26, $P = 0.094$, PMA \$1744 vs. \$1364). Physician costs were the same at \$128 per week (PMA \$6650). The weekly mean total cost for health care delivery was 20% less for HNHD (\$1082 vs. \$1322, $P = 0.006$), with projected mean annual costs more than \$10,000 lower (\$56,394 vs. \$68,935).

Conclusions. HNHD provides about three times as many treatment hours at nearly a one-fifth lower cost, with savings evident even when only program and funding-specific costs are considered.

Key words: renal replacement therapy, cost analysis, dialysis, end-stage renal disease, chronic renal disease, adequacy of dialysis, consumables for dialysis.

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Hemodialysis patients traditionally receive three weekly treatments of four hours each, yet more frequent and lengthy sessions of dialysis are associated with improvements in clinical parameters [1–3]. Home nocturnal hemodialysis (HNHD) is a technique developed in Toronto in 1993, in which a patient performs treatments in their home while asleep [4]. These individuals place themselves on dialysis at night and disconnect themselves the following morning. On average, patients receive six treatments per week, each lasting eight hours. In this group, improvements have been seen in phosphate and potassium levels, blood pressure, sleep patterns, ventricular hypertrophy and in quality of life (abstract; Brissenden et al, *J Am Soc Nephrol* 9:168A, 1999) [2, 5–10].

Most research has concentrated on the clinical effects of HNHD and few formal analyses of the costs of this technique are available. Examinations of program budgets are insufficient, as they fail to consider overall healthcare expenditures. One study provided favorable analyses of HNHD costs through examination of administrative databases, but these projections were performed without prospective patient-level data [11]. The general belief suggests that the cost of HNHD is less than conventional in-center hemodialysis, which has been estimated to cost between CAN\$80,000 to CAN\$95,000 per patient-year [12–14].

A patient performing HNHD as practiced in Toronto receives five to seven dialysis treatments per week, as compared to conventional in-center hemodialysis (IHD) where patients receive three treatments per week. We conducted a one-year prospective descriptive costing study, to determine the costs of this newer method of dialysis, and to test the hypothesis that HNHD could provide these additional dialysis treatments at a lower total cost of health care delivery than IHD.

METHODS

Patient population

All active patients enrolled in the HNHD program at the Humber River Regional Hospital (HRRH) in Toronto

were eligible, except those on the modality for less than three months during the study period. Selection criteria for this program required that the patient show a capacity for self-care training, functional literacy in English, and a life expectancy of more than one year. In addition, the patient was required to have sufficient manual, visual and auditory abilities unless a spouse or other family member could assist during treatments.

Selection criteria for the control hospital required that the hospital be university affiliated, located in the greater Toronto area, have an in-center hemodialysis program of sufficient size, and not have a home hemodialysis program in operation. Based on these criteria, the control group was formed from patients attending the hemodialysis clinic at St. Michael's Hospital in Toronto (SMH). Control patients were selected based on suitability for home dialysis. The SMH program medical director, who was uninvolved with this study, was asked to screen all SMH hemodialysis patients and identify those appropriate for home hemodialysis. Those selected were considered eligible if they expressed an interest in home hemodialysis after description of the modality, and might consider switching from center-based hemodialysis. As new patients entered both programs during the study period, they were screened for eligibility and approached regarding enrollment.

Signed consents approved by local and university ethics review boards were obtained from all study subjects.

Costing methods

Prospective costing data were collected from January 1, 2000 to March 1, 2001. The primary analysis involved calculation of a weekly total cost of health-care as viewed from the perspective of the health-care provider. Costs were expressed in year 2000 Canadian dollars. An on-treatment analysis was used, and opportunity costs were excluded. We assumed that either dialysis modality was available to a patient, and so did not include an analysis of start-up costs or construction of new facilities. Capital costs were amortized over seven years, reflecting the expected modality survival.

For cost items that were calculated on a per-treatments basis, the weekly cost was determined by multiplying each patient's per-treatment cost by their weekly average number of treatments.

Because programs typically have annual rather than weekly budgets, a projected annual cost was calculated for each patient by multiplying their weekly cost by 52.14.

Secondary analyses included a program-specific cost including only the cost of direct hemodialysis materials, staffing, overhead and support, and depreciation, and a unit-specific cost that examined only direct hemodialysis materials, staffing and overhead, and support costs.

Number of treatments

Methods were available to track the number of dialysis treatments provided to each patient during the study period. SMH tracks membrane usage at the patient level as part of a dialyzer reuse program. HRRH has contracts with private companies, which provide data for each treatment on a patient-by-patient basis. A 5% random sample of treatment counts was audited against alternate sources (run sheets, HNHD monitoring logs) to assess accuracy.

Censoring of data

As this was an on-treatment analysis, it was expected that patients would have uneven durations of follow-up due to either late entry (following modality training or program transfer) or early exit from their initial modality (due to death, transplantation, or change of modality type). To allow for variable follow-up, costs were expressed as the weekly cost of health care for each patient. Patient data were collected only while the patients were on their initial modality, and a mean weekly cost was calculated only for the time on-treatment.

Direct hemodialysis materials costs

Direct hemodialysis materials expenses consisted of all consumables for hemodialysis, including the dialysis membrane, medications delivered for dialysis (for example, heparin), and additives to the dialysate (potassium chloride, calcium chloride, and fleet phosphasoda), as well as costs of monitoring treatments.

As SMH has a dialyzer reuse program, a programmatic analysis was performed to calculate the average cost of reprocessing a membrane as well as the cost of purchasing a fresh membrane. For each patient, the number of fresh and reprocessed membranes used through the study period was used to calculate their total membrane cost.

Access-specific connectivity costs including cannulae for grafts and fistulae, and catheter caps for in-dwelling lines were calculated.

A portion of the HNHD group was remotely monitored during their treatments by either dedicated phone line or the Internet. These costs were included for those patients who were monitored during the study period.

As not every item applied to each patient, an individualized per-treatment cost was determined accounting for type of access, monitoring status, and hospital-specific items. This calculation accounted for change of access type and monitoring status through the study period.

Staffing

Salary and benefits for staff directly involved in the provision of dialysis care were determined through detailed hospital records. This included nursing staff, assistants, technical personnel, and other professionals (such as, pharmacists, social workers and dieticians). Manage-

Table 1. Overhead and support costs

Category	Allocation unit
General hospital administration	Paid hours
Medical records	% Dictations
Housekeeping	Square meters[a]
Engineering	Square meters[a]
Laundry	% Overall
Porters	Paid hours
Utilities	Square meters[a]

[a] Percentage of overall hospital floor space

ment personnel were included to the level of the unit manager, as were non-medical personnel such as secretaries and administrative assistants.

To further examine the differences in staffing costs, an analysis of staffing complements for the two programs was performed. The mean number of full-time equivalents (FTE) for each staff category during the study period was determined weekly on a per-patient basis.

Overhead and support

Overhead and support consisted of costs for support services including housekeeping, dictation, laundry, engineering, and porters. Also included were costs for administrative personnel above the level of unit manager, the costs of consumables unrelated to the direct provision of dialysis (for example, office supplies), and utilities. At SMH these costs are assigned through a single charge as a percentage of the dialysis program annual budget. At HRRH, a series of calculations were performed to allocate these costs to the HNHD program (Table 1).

Medications

For each patient a drug profile was generated that tracked medication use on a daily basis. All oral, parenteral and over-the-counter medications were included except those listed as a direct hemodialysis materials cost or those delivered during an in-patient admission (which were captured as an Admission and Procedure cost). The physician order section, pharmacist notes, and computer-based pharmacy records were reviewed periodically. By determining the start and discontinuation dates of all medications, a daily drug profile was generated for each patient for every day of the study period. Drugs taken only as needed were assigned an estimated number taken per day based on a patient interview.

A series of methods were used to assign a cost to each medication. The Ontario Ministry of Health Drug Benefit Formulary specifies the cost that the Ontario government has agreed to pay for most medications. For those not listed, hospital formularies and program purchase contracts were used to determine a drug's cost. For medications not listed in these sources, the drug acquisition cost for a major international pharmacy chain was used. It was assumed that a generic form of each medication was purchased unless specifically indicated in the patient record. A 5% mark-up was added for medications acquired from pharmacies outside of the hospital. A dispensing fee of CAN$8.50 was added for all oral medications for each 90 days of use.

In addition to overall medication usage, three categories of medications were selected prospectively for separate analysis: anemia therapy (including erythropoietin and iron preparations), antibiotics, and cardiovascular medications (including antihypertensives, anti-anginals and therapies for ventricular dysfunction).

Admissions and procedures

Each in-patient admission was identified for all patients. Each hospital had existing methods for tracking in-patient direct and indirect costs at a patient level. Out-patient interventional procedures were identified also for each patient, with costs based on the government Schedule of Benefits, which included fees for physicians, facilities, staffing and expendables.

Laboratory tests and medical imaging

The performance of laboratory and imaging studies were tracked through a periodic review of the test results section of the patient chart, as well as each hospital's laboratory database. The cost of radiology tests was determined from the government Schedule of Benefits, including both physician and technical fees. The cost of lab tests was based on charges by a private lab company that provided the bulk of out-patient lab services. In-hospital test costs were based on fees charged at one hospital (SMH).

Physician fees

The Ontario government Physician Schedule of Benefits was used to determine the cost of physician services for the provision of dialysis care and for other services such as consultations and follow-up visits.

Depreciation/capital costs

All forms of hemodialysis incur capital expenses for equipment. The cost for acquisition of dialysis machines and water treatment equipment was determined. The HNHD program required additional one-time items such as the initial setup of all equipment in the home and enuresis sensors used to detect blood leaks.

As all patients performing HNHD must be trained to perform the modality, the cost of training also was considered a depreciable expense. The average cost of training was determined by review of HRRH records, and included staffing time as well as consumables used through the training period.

Capital items were categorized as either reusable (that is, able to be used for a new patient if the current patient

Table 2. Demographics

	IHD ($N = 23$)	HNHD ($N = 33$)	P value
Sex % *male*	69.6	75.8	0.84
% with diabetes	6.1	13	0.67
% with CAD	8.7	15.2	0.76
% with CHF	4.3	21.2	0.12
% Post-secondary education	43.5	36.3	0.89
Age *years*	47.4 ± 9.8	45.4 ± 10.0	0.48
Duration ESRD *years*	5.8 ± 5.6	7.7 ± 6.5	0.26

dies or changes modality), or non-reusable. Examples of reusable items included dialysis machines, water purification equipment, and dialyzer reuse technology. Examples of non-reusable items included blood and other sensors, as well as the training costs for HNHD patients. Reusable items were amortized over seven years, while non-reusable items were amortized over five years. A sensitivity analysis was performed to test the effect of shorter amortization periods.

Statistics

Demographic variables were analyzed as means (such as age) and proportion (such as sex) as appropriate. Cost variables were examined through comparison of weekly mean values. Distribution shape and normality was checked for all variables using normal and detrended normal Q-Q plots and the Kolmogorov-Smirnov test with Lilliefor's significance correction. Normally distributed means were compared using the Student t test, while variables failing normality testing were examined using the Mann-Whitney U test. Chi-squared tests were used for categorical variables. A significance level of 0.05 was used for all tests.

RESULTS

Patient population

A total of 38 patients participated in the HNHD program during the study period. Five were on the modality for less than three months during the study period. All remaining 33 patients agreed to participate.

One hundred and eighty-two patients from the IHD program were screened, and 29 were considered eligible for home hemodialysis. Of these 29, three refused to consider home dialysis and three declined to participate in the study, leaving 23 control patients. Over 2/3 of the IHD patients were performing in-center self-care hemodialysis. The HNHD and IHD groups had similar demographic features (Table 2).

By the end of the study period, 30 HNHD patients were still on the modality, with three patients having received a transplant during the study period. Of the 23 IHD patients, one died and two were transplanted by the end of the study period.

Intensity of treatment

A total of 2609 patient-weeks of data were collected. The mean number of weeks on modality during the study period was 46 ± 12 for HNHD and 48 ± 9 for IHD (P = NS). The weekly average number of treatments for HNHD was almost two times greater for HNHD than IHD (5.7 ± 0.9 vs. 3.0 ± 0.4, $P < 0.001$). Assuming a four-hour average treatment time for IHD, and a minimum treatment time of six hours for HNHD, the total weekly dialysis time was at least 2.8 times greater with HNHD (34.0 vs. 12.1 h/week, $P < 0.001$).

The measurement of dialysis adequacy in intensively dialyzed patients remains controversial. In the absence of consensus, we calculated the single session and weekly single pool Kt/V during a representative period of the study. The single session Kt/V for the HNHD group was 1.59 ± 0.22, and was 1.36 ± 0.17 for the IHD group. Weekly Kt/V was 9.1 for the HNHD group, and 4.1 for the IHD group.

Total costs

Table 3 summarizes the weekly and projected annual costs for each modality. The overall cost of health care delivery for HNHD was 20% lower than for IHD ($1,082 ± $155 vs. $1,322 ± $348, $P = 0.006$). The projected annual cost for all categories was more than $10,000 less with HNHD than IHD ($56,394 vs. $68,935). When the scope was restricted to program- and funding-specific costs HNHD remained the less expensive option (Table 4). All but five of the IHD patients had mean total annual costs higher than the mean total annual cost of the HNHD group.

Home nocturnal hemodialysis achieved this cost saving through reductions in several categories. Staffing costs were half that of IHD, and overhead and support costs were reduced by two-thirds. There was a trend toward fewer days admitted to hospital for the HNHD group (1.8 vs. 6.8 admit-days/patient-year, $P = 0.13$), resulting in a total cost for admissions and procedures that was 15% of the IHD cost (P = NS). There was also a trend suggesting 25% lower medication expenses in the HNHD group ($P = 0.08$).

These cost reductions made up for categories where HNHD was more expensive. Costs for direct hemodialysis materials were more than two times higher than IHD. Depreciable items were more than seven times more expensive for HNHD. The costs of outpatient labwork trended toward being 25% higher for the HNHD group ($P = 0.094$). The mean HNHD training cost in 2000 was $10,201 per patient trained.

Direct hemodialysis materials costs

The cost of 73 items required for the performance of hemodialysis was tracked. These items ranged in price

Table 3. Summary of costs

	Measured weekly costs			Projected annual costs	
	IHD	HNHD	*P* value	IHD	HNHD
Staff	$423	$210	<0.001	$22,056	$10,932
Direct hemodialysis materials	$126	$318	<0.001	$6,575	$16,587
Drug	$231	$172	0.082	$12,029	$8,989
Overhead and support	$238	$80	<0.001	$12,393	$4,178
Physician fees	$128	$128	N/A	$6,650	$6,650
Admits/procedures	$134	$23	0.355	$6,997	$1,173
Depreciation	$17	$118	<0.001	$871	$6,139
Lab tests/imaging	$26	$33	0.004	$1,364	$1,744
Total	$1,322	$1,082	0.006	$68,935	$56,394

All costs are expressed in year 2000 Canadian dollars.

Table 4. Cost comparison by costing perspective

	IHD	HNHD	*P* value
All Costs			
Per treatment	$434 ± $95	$194 ± $37	<0.001
Per week	$1,322 ± $348	$1,082 ± $155	0.006
Projected annual	$68,935	$56,394	
Program specific costs[a]			
Per treatment	$265 ± $5	$129 ± $5	<0.001
Per week	$804 ± $97	$726 ± $93	0.012
Projected annual	$41,895	$37,837	
Funding specific costs[b]			
Per treatment	$260 ± $5	$107 ± $4	<0.001
Per week	$787 ± $97	$608 ± $93	0.001
Projected annual	$41,024	$31,698	

[a] Costs of direct hemodialysis materials, staffing, overhead and depreciation
[b] Costs of direct hemodialysis materials, staffing and overhead

Table 5. HNHD staffing composition

	Staffing mean full-time equivalents (FTE)
RN	2.1
Technical	2.0
Clerical	1.0
Environmental	0.75
Social worker	0.25
Dietician	0.33
Pharmacy	0.50

Table 6. Selected staffing complements

	Staffing mean full-time equivalents (FTE) per patient	
	IHD	HNHD
RN	0.22	0.06
Technical	0.04	0.06
Clerical	0.02	0.03
Environmental	0.02	0.02
Social work	0.01	0.01
Dietician	0.01	0.01
Pharmacy	0.01	0.01

Table 7. Medication costs

	IHD	HNHD	*P* value
EPO			
Per week	$182 ± $124	$110 ± $108	0.029
Projected annual	$9,468	$5,712	
IV iron			
Per week	$1.15 ± $3.89	$27.79 ± $30.02	<0.001
Projected annual	$60	$1,449	
Cardiovascular			
Per week	$14.62 ± $9.91	$3.66 ± $5.32	<0.001
Projected annual	$762	$191	
Antibiotics			
Per week	$0.81 ± $1.48	$3.41 ± $4.40	0.003
Projected annual	$42	$178	

from $0.01 to $11.00. The average cost per treatment for these items was about a quarter higher with HNHD than IHD ($56.16 ± $3.55 vs. $41.64 ± $5.08, $P < 0.001$). The cost to remotely monitor a patient via Internet for all treatments over a one-year period was $3,096.

Staffing

The number of patients and staffing levels changed across the study period for both programs. Table 5 outlines the typical staffing level for the HNHD program, serving approximately 35 patients. The specific comparative staffing analysis demonstrated that the mean number of full-time-equivalent staff for each staffing category was similar for both groups with the exception of nursing (Table 6). The number of nursing staff per patient was about 3/4 less for HNHD.

The staff for both hospitals shared the same unions for nursing, technical and support staff, leading to a shared pay scale for the majority of the employees.

Medications

Table 7 outlines the differences seen in the pre-specified medication categories. Erythropoietin (EPO) use and cardiovascular medications were significantly less in the HNHD group, while IV iron preparations and antibiotics were significantly more. Significantly less EPO was used by the HNHD group (mean weekly dose 7,301 ± 7,282 units vs. 11,869 ± 8575 units, $P = 0.036$).

Table 8. Capital amortization period sensitivity analysis

Reusable item[a]	Non-reusable item[b]	Weekly total cost			Projected annual total cost	
Amortization period *years*		HNHD	IHD	*P* value	HNHD	IHD
7						
	5	$1,082	$1,322	<0.01	$56,394	$68,935
	4	$1,091	$1,322	0.01	$56,870	$68,935
	3	$1,106	$1,322	0.02	$57,665	$68,935
	2	$1,136	$1,322	0.08	$59,255	$68,935
5						
	5	$1,114	$1,329	0.02	$58,085	$69,283
	4	$1,123	$1,329	0.04	$58,562	$69,284
	3	$1,138	$1,329	0.07	$59,357	$69,284
	2	$1,169	$1,329	0.25	$60,947	$69,284

[a] Reusable items include dialysis machines, centrifuges, water treatment and reuse equipment

[b] Non-reusable items include patient training, sensors, tourniquets, and home specific equipment

Physician fees

In Ontario, physicians providing dialysis care receive a weekly modality-independent fee for all medical services, leading to an identical weekly cost of $127.55 per patient (projected mean annual cost of $6650). Outside of nephrologic care, there were few physician encounters in both groups that did not lead either to an admission or an intervention. Although attempts were made to track these remaining physician encounters, charting and patient recall of these events was found to be unreliable. The mean number of identified encounters was small and similarly judged too unreliable for analysis.

Sensitivity analysis

As depreciable expenses were significantly different between the groups, and a long amortization period was chosen for the primary analysis, a sensitivity analysis was undertaken to determine the impact of shorter amortization periods on the total weekly and projected annual costs. HNHD remained the less costly option in all scenarios. When a seven-year period is selected for reusable items, the cost difference is statistically significant only if the patient remains on the modality for more than two years. If the reusable amortization period is reduced to five years, a patient must stay on HNHD for more than three years before statistical significance is reached (Table 8).

DISCUSSION

While there are many estimates of the cost of conventional hemodialysis, there exists no prospective patient-level estimate of the cost of home nocturnal hemodialysis. Our first goal was to produce an estimate of the cost of this new modality. To our knowledge, this study examined the world's first and largest home nocturnal hemodialysis program. While this yielded an assessment of an established and mature program, the number of patients enrolled remained small relative to most in-center hemodialysis programs, affecting the variability of our results. Additionally, our results describe the findings in a single center. New and smaller programs may not realize some of the economies of scale seen here, while established programs may exceed these results through additional efficiencies. Furthermore, this mature nocturnal hemodialysis program includes a broad mix of patients, with varying levels of medical complexity. It is likely that new programs will select healthier patients initially. This is not likely to significantly affect the costs of performing HNHD, but may change the savings seen in other areas such as hospital admissions. As programs mature, and the penetration of HNHD increases, it is likely that the reductions in non-modality expenses will improve.

Although we calculated the cost of depreciable equipment and training, we did not calculate the cost of new facilities or start-up costs, which could be substantial in a new program. For these reasons, new HNHD programs may not fully realize the overall cost savings described here in the initial phases. Potential savings will also change as the patient mix shifts away from the healthiest individuals. Additional research will be needed as the use of HNHD spreads, and as existing programs grow.

In addition to studying the cost of HNHD, we attempted to compare the costs to those seen in a similar group of individuals who were performing in-center hemodialysis. To minimize the selection bias inherent in a non-randomized design, we selected a hospital where there were patients eligible for home hemodialysis, but where a home hemodialysis program did not exist. Our selection process produced groups that were demographically similar, with a trend toward more congestive heart failure at baseline in the HNHD group (HNHD was used as "rescue" therapy for some individuals with frequent exacerbations of heart failure). While the two groups were similar, neither group is similar to the "average" hemodialysis patient. The individuals in this study tended to be younger, were unlikely to have diabetes, and had been on dialysis for a prolonged period. Our conclusions, therefore, should not be generalized to the broader dialysis population. Although this study did not address the question of who is capable of performing home nocturnal hemodialysis, our selection process identified less than 16% of the patients from the SMH dialysis unit as being potentially eligible.

While selection bias was minimized by the selection of our control hospital and patients, this bias can only be fully avoided through the performance of a large-scale prospective trial, with randomization of patients to their form of dialysis.

While methodological requirements led to the selec-

tion of the Humber River Regional Hospital and St. Michael's Hospital for our study, neither hospital had pre-existing patient-level infrastructure for tracking of out-patient costs. Our study team was able to collect microcosting data for all categories except overhead and support, where cost estimates were attributed at the program level, rather than at the level of the individual patient. We would encourage hospitals participating in innovative therapies such as HNHD to develop the ability to track all costs at the patient level.

Differences were seen in usage of selected medications (EPO, IV iron, cardiac medications and antibiotics). This study cannot answer whether these differences were related to patient, physician or modality-specific effects, but suggests directions for future research.

The number of days spent in-hospital was lower than historically predicted for both groups, with a trend toward fewer hospital admissions for the HNHD group. As the patients were similar at baseline, and since it is less likely that physician practice patterns drove these results, the possibility arises that HNHD impacts on the requirement for hospital admission. This also should be addressed specifically in future research.

Patients performing HNHD received almost twice as many dialysis treatments, and triple the number of dialysis hours than those performing conventional IHD. Despite this, the projected annual total cost for health care was more than $10,000 lower for the HNHD group. Savings in staffing, overhead and support, and admissions and procedures overcame cost increases for direct hemodialysis materials and the cost of depreciable items. Staffing cost reductions were primarily driven by a lower requirement for nursing staff. Although some of the savings found in this study (for example, hospitalizations) would not be realized at the dialysis unit level, our results suggests that HNHD is the less costly option even when costs only directly borne at the dialysis provider level are included. While HNHD is the less costly option for every amortization period in our sensitivity analysis, the cost savings are only statistically significant if the patient remains on the modality for at least three years.

We encourage dialysis programs to consider home nocturnal hemodialysis as an addition to in-center hemodialysis, not only due to the clinical improvements, but also as a method of constraining costs and managing program growth.

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